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Comparative Palatabilities of Silages

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COMPARATIVE PALATABILITIES OF SILAGES

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SUMMARY

Based on nineteen separately described experiments using 10 kinds of silage the following conclusions can be drawn regarding differences in palatability of the silages.

Corn silage was more palatable than most meadow crop silages.

The addition of some form of fermentable carbohydrate usually made a more palatable silage from legume-grass mixtures than did the untreated crops.

Silage from a mixture of untreated sweet sudan and soybeans was nearly as palatable as corn silage and needed no conditioner or preservative.

Silages from corn-treated meadow crops were definitely more palatable than those from untreated meadow crops. Moldy corn serves satisfactorily as a treatment for meadow crop silage.

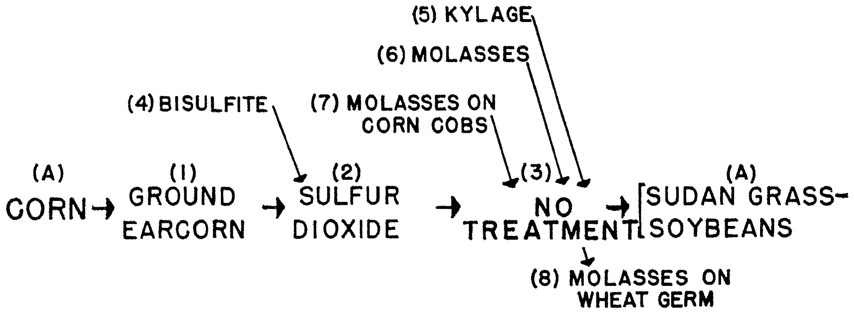
Molasses-treated meadow crop silage was usually more palatable than untreated meadow crop silage. The amount of dry matter in the crop ensiled, the amount of molasses used and the amount of dry matter in the molasses carrier all appeared to be factors affecting the palatability of the final product.

Silage from meadow crop treated with calcium formate and sodium nitrite (Kylage) was more palatable than untreated meadow crop silage of high moisture content.

Silages made using sulfur dioxide (SO_2) and sodium metabisulfite (bisulfite) as preservatives were both highly and about equally palatable. The use of bisulfite is preferable because of safety and of ease of distribution in the silage crop.

Silages of high palatability result in high intake of roughage dry matter and in decreased need for grain.

OBSERVED ORDER OF
→ DECREASING PALATABILITIES OF SILAGES →
IN THESE EXPERIMENTS



(A) = CROPS ENSILED

(1)......(8) = IDENTIFICATION ONLY, OF TREATMENTS <u>ON MEADOW CROPS</u>. RELATIVE PALATABILTIES OF (5), (6), (7) TO (1), (2), (4) OR (A) ARE <u>NOT</u> INDICATED BY THEIR POSITION ON THIS DIAGRAM.

→ ARROW POINTS TO THE TREATMENT WHICH PRODUCED THE LESS PALATABLE OF TWO SILAGES COMPARED DIRECTLY BY FEEDING.

INTRODUCTION

Among dairy cattle feeds, roughages are of the greatest importance for economical milk production. Total digestible nutrients can usually be obtained from roughages at much lower cost than from concentrates or milling by-products. Palatability of roughages or other feeds may affect their feeding value as much as the nutrient content. Roughages that become too mature before harvest have a high crude fiber and lignin content and low digestibility. Roughages that are rain-damaged or sun-burned during curing, have lower palatability and they usually are not consumed in as large amounts as undamaged feeds.

The value of silages depends both on their chemical composition, or nutrient content and on the ability or desire of cows to eat them in such amounts that they can get a major part of their energy needs from this source.

Webster defines acceptability as "capable, worthy or sure of being accepted". Two silages available for feed might both be acceptable according to this definition. Either one offered alone might be eaten readily and seem to be entirely satisfactory.

A palatable feed is defined as one that is agreeable to the taste. One of two silages might be more agreeable to the taste than the other. The greater palatability of the one silage should make it a potentially greater component of the entire day's ration than the other, and thus contribute more to the economical production of milk. Consequently palatability of silage is especially important where dairymen need to make silage a high proportion of the roughage intake. Conversely, palatability of silage is of less importance when hay constitutes the major portion of the roughage or when dry cows are on a maintenance ration.

When a herd of cows is fed a single lot of silage as the only roughage, the amount eaten by the individual is a result of the absolute palatability of that silage. When hay is fed comparative palatability of the silage in relation to the hay becomes important.

When two silages are fed in a divided manger and are available to the animal at the same time their comparative palatability is determined by the amount of each that is eaten. Acceptability or absolute palatability may be determined in a reversal type of experiment where a group is fed one silage in one period and another silage in a second period.

Corn was the crop of preference in the United States when silos were coming into use, 1881-1900. During that time corn silage in dairy rations displaced corn stover with a resulting increase in milk production. This was probably due to a combination of more energy in the rations, higher roughage quality and increased feed consumption partly because of the greater palatability of silage compared to corn stover and more favorable water intake. Canadian workers had found by 1905 that they could get a yield of mammoth red clover of 32 tons per acre, thus exceeding that of corn under their conditions of soil and climate. Elting (**16**) in 1935 applied the findings of Reed and Fitch (**34**) to practical ensiling of soybeans by addition of molasses. His publication gave impetus to the use of molasses in the production of legume silages.

Treatment of meadow crops at the time of ensiling with additives has resulted in improvement in palatability of the finished silage. Added chemical preservatives usually decrease the production of butyric and propionic acids and increase the proportion of acetic and lactic acids. These changes make the silage more acceptable to the cow and less objectionable to man. The use of some form of carbohydrate as an additive provides material for greater fermentation. Hunter (**23**) in 1918 found that the addition of a carbohydrate supplement to ensiled material resulted in higher acidity and less protein decomposition. Molasses, ground cereal grains, milling by-products and dried whey have since been used in this way and are called "conditioners". The distinction between preservatives and conditioners is that preservatives prevent or at least reduce fermentation while the conditioners direct the course of fermentation and even assist fermentation, by providing a favorable source of carbohydrate for acid formation.

Both grasses and legumes are useful for production of silage. Wilson and Webb (41) in 1937 predicted the use of mixed grasses and legumes to obtain the objectives of increasing both the protein and fermentable carbohydrate content. Mixtures of the two are now considered practical on most farms since yields are usually greater from mixtures grown together than from either grass or legume grown alone. A variety of weeds also grow with forage crops. Most of these weeds have some feeding value. In this report the mixtures of grasses, legumes and weeds in such proportions as they grew together in the field are called the meadow crops. The resulting silage is **meadow crop silage.**

In general, different first-quality roughages should be of equal value on a dry matter basis, if properly supplemented. Legume or mixed grass-legume silages would be superior to non-legume silages in dairy rations in that they need little or no supplemental protein.

EXPERIMENTAL

The experiments described below were designed to find (a) the comparative palatability of the various silages and (b) their value for milk production.

These experiments were conducted from 1947 through 1956. Two series of experiments to show comparative palatability were conducted in the seasons of 1949-50 (Series I) and 1955-56 (Series II) and were too short in duration to check the effects upon changes of body weight. The animals used for the latter series were in late lactation or dry and the experiment was so designed that milk production could be unimportant. The remaining experiments were of longer duration and both milk production and weight changes were recorded.

EVALUATION OF EXPERIMENTAL TECHNIQUES

UNTREATED MEADOW CROP VS. UNTREATED MEADOW CROP SILAGES

Two silos were filled with meadow crop in 1955 for experimental use (Series II) the next winter. The crop for both was cut from the standing position. One was ensiled without treatment and used as reference silage. Layers within the other silo were as follows:—(1)

Kylage-treated[1] (2) corn-treated (3) Omolass-treated[1] (4) treated with molasses on ground corn cobs (5) untreated and (6) corn silage. Each of the layers was fed in turn in comparison with the reference silage to 10 Jersey cows in divided mangers. Each cow was fed 7 lb. of alfalfa hay and 4 lb. of grain.

To evaluate the procedures reference silage (untreated meadow crop) was fed in comparison to untreated meadow crop. To avoid the (Fig. 1) possibility that the cows might form a habit of eating from one side of the manger in preference to the other, and thus bias the experiment, the position in which the two silages were fed was alternated from day to day.

At this level in the silos the dry matter content was 20.75%. An attempt was made to feed enough of each silage so there would be 5 lb. refusal of each type of silage. This refusal assured that the cows ate all the silage of the two kinds they wanted.

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[1]Kylage is the proprietary name for a mixture of calcium formate and sodium nitrite. Omolass is molasses dried on corn germ meal.

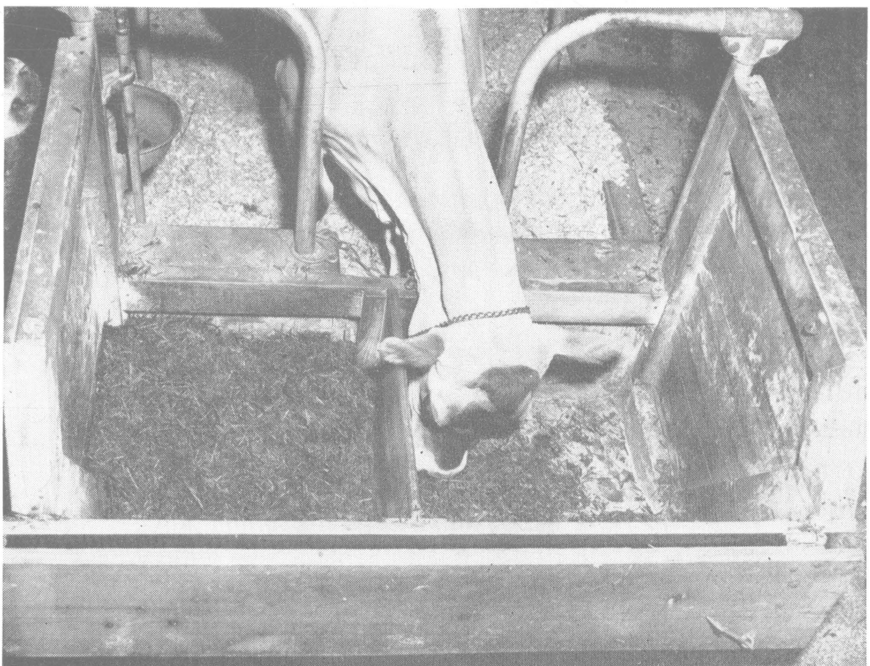

Fig. 1.—This is the divided manger used in tests. Feeds were alternated from day-to-day so that cows would not form habit of eating only one part of ration.

For an 8-day period the amount of reference silage eaten was 2,130 lb. and of the compared untreated meadow crop silage was 2,153 lb., a difference of only 1%. One cow ate about 50% more of the reference silage than of the other untreated silage. Two other cows ate more of the experimental silage than of the reference silage. The writers are unable to explain these evidences of preference other than being due to variations in the plants in the mixture that was ensiled. The crop was grass and legume, cut from 3-acre fields, varying in composition from field to field. Variations in preference for feeds occur in practical herds. Unless the preference for one silage is shown by a majority of the animals this preference would appear not to be of practical significance.

COMPARISON OF TWO HIGH-ENERGY SILAGES

Corn silage has been regarded as the pre-eminent high-energy silage. Corn silage is highly palatable and yields well, but compared to grass silages corn silage is low in protein and mineral content. Because of these facts the following experiment was planned.

SWEET SUDAN-SOYBEAN SILAGE VS. CORN SILAGE

Experiment 1. Sweet sudan grass and soybeans were (Series I) grown together. A botanical count made at harvest showed the proportion by weight to be sudan grass 73%, soybeans 13% and weeds 14%. The crop was cut from the standing position with a field chopper. Difficulty was experienced in adjusting the chopper reels to avoid knocking the sudan over and still pick up the soybeans. Other experiences indicated that growing the two crops separately but in the same field would be better than growing the two crops in a mixed stand. The reels could be properly adjusted for each crop and the cut crops could be layered on the wagon.

This silage contained 21% dry matter. The corn silage with which it was compared contained 29% dry matter. A 13.5% protein grain ration was fed with both silages at the rate of 1 lb. for each 3.5 lb. of 4% fat-corrected milk.

Ohio-grown alfalfa hay was fed at rates varying from 12 to 16 lb. per day depending on the body weight of the individual cow.

Both silages were fed in equal amounts and each in excess of the cow's consumption so that there would be refuse to be weighed back. The silages were put in a divided manger to keep the silages separated yet equally available to the cows.

Over a period of 26 days, eight cows preferred corn silage whereas four preferred sweet sudan-soybean silage.

Experiment 2. Prior to this trial the cows had been fed sweet sudan-soybean silage and untreated meadow crop silage. When changed to corn silage the entire group preferred corn silage for four days after which they showed a less marked preference for corn silage, some showing a preference for sweet sudan-soybean silage. There was considerable variation in the latter silage which at least partially accounts for the changes in preference with advance in the feeding period.

Palatabilities of these two silages were about the same.

The average refuse per cow per day of sweet sudan-soybean silage was 3.8 lb. and of corn silage was 2.9 lb. A daily difference in refusal of 0.9 lb. is small for cows fed 50 or more pounds of silage daily.

The cows produced 29.2 lb. of 4% milk daily on corn silage and 27.5 lb. while on sweet sudan-soybean silage, a significant difference.

The sweet sudan-soybean crop as ensiled contained 11.9% protein on an air dry basis or 2.5% as fed. When ensiled at the last of August the crop contained 10.7% of sugar (dry basis). When the silage was fed the sugar content was only 0.73% the most of it undoubtedly having been fermented resulting in a pH of 3.85 which corresponds to that of a well preserved corn silage.

COMPARISON OF HIGH-ENERGY AND HIGH-PROTEIN SILAGES

Hills (**21**) in 1891 compared clover silage with corn silage and concluded that clover silage was less desirable. Because of advances in the technique of ensiling legumes, further comparison of meadow crop silage with corn silage was logical.

Experiment 1. A comparison of acceptability or absolute palatability corn silage **vs.** untreated meadow crop silage was made in a double reversal type of experiment. The cows were adjusted to the rations in a preliminary 20-day period which was followed by three 30-day experimental periods separated by 10-day transitional periods. Each group was composed of seven Holsteins and three Jerseys. One group was fed corn silage and the other meadow crop silage during the first 30-day period. At the beginning of the 10-day transitional periods the silages were reversed, thus each group received both silages; furthermore, both silages were fed for an equal period of time, a comparison of absolute palatability.

At the start of the first transitional period three cows were added to each group. They had a 10-day period for adjustment to the ration followed by a single reversal type of experiment of two 30-day periods separated by a 10-day transitional period.

Dry matter analyses were made of each silage during each 10-day period. The weighted average percent of dry matter for corn silage was 24.5 and for meadow crop silage was 27.7.

Alfalfa hay was fed to both groups at a constant ratio to body weight.

The grain was 13.5% protein, and was fed at the rate of one pound for each 3.5 lb. for Holsteins and one pound for each 2.5 lb. for Jerseys.

Both silages were highly acceptable to the cows. The silages were fed slightly in excess of consumption and the refuse was weighed back.

Table 1 summarizes the data for both the double reversal and the single reversal feeding trials. Since there were no appreciable differences in feed intake other than silage or in milk production while the cows were on the two silages the data for the two trials were combined as weighted averages. There was about a 5% difference in pounds of silage consumed. The daily weighted dry matter intake per cow was 13.4 lb. in corn silage and 14.3 in meadow crop silage.

While the cows were on corn silage they gained 0.21 lb. body weight per day and on meadow crop silage, 0.46 lb.

TABLE 1.—Weighted Averages of Feed Eaten per Cow, per Day, During a Comparison of Corn and Meadow Crop Silage

		Silage					
	Grain	Corn	Grass	Hay	4% Milk	Dry matter in silage	Total intake of dry matter
	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)
Double Reversal Experiment:							
Corn Silage Group	7.4	54.6	----	11.7	28.7	13.2	29.8
Meadow Crop Silage Group	7.4	----	51.7	11.7	28.5	13.9	30.6
Single Reversal Experiment:							
Corn Silage Group	9.3	56.0	----	11.5	36.3	14.2	32.0
Meadow Crop Silage Group	9.6	----	54.8	11.5	36.5	16.0	33.9
Combined Experiments:							
Corn Silage Group	7 8	55.5	----	11.8	30.0	13.4	30.1
Meadow Crop Silage Group	7.8	----	52.3	11.8	29.9	14.3	31.1

The β-carotene content of the corn silage was fairly uniform during the experiment except that it was low during the last 10 days. Corn silage averaged 61 μg/g. as contrasted with 100 μg/g. in the meadow crop silage and 8.6 μg/g. in the alfalfa hay. The B-carotene content of the Jersey milk was nearly double that of the Holstein milk. When the feeding was changed from corn silage to meadow crop silage the carotene values of the milk increased from 38 μg/g. to 44 μg/g. A corresponding decrease occurred when the feed was changed back to corn silage. In either case silage was, quantitatively, a more important source of carotene than the hay. Tucker **et al.** (39) had previously shown that when "grass" silage made up a high proportion of the roughage of the ration the carotene content of the milk was increased.

When the silages were changed at the beginning of the last transitional period both groups were fed equal weights of both silages. The amounts of silage remaining at 1 hr. and 45 min. after feeding showed that 11 cows of the 14 which had been on meadow crop silage before the transition showed a decided preference for corn silage and that 6 of 13 cows on corn silage before the transition showed a less pronounced preference for meadow crop silage. The evidence indicates that this corn silage was more acceptable than the meadow crop silage. Krauss (**29**) pointed out that grass-legume silages in the range of 25 to 40% dry matter without preservatives are as acceptable as those of silages of lower dry matter content made with preservatives. Dexter (**13**) found a higher pH in silages of high protein content. This relationship applies to all untreated leguminous silages and to grasses cut at an early stage of growth. Bacterial fermentation continues until a lower pH is attained or until the fermentable materials are exhausted at which point their activity is curtailed. Barnett (**6**) emphasizes the relative importance of lactic acid formation which predominates in the fermentation of high-dry-matter silages.

Experiment 2. A second experiment to determine comparative palatability was conducted for a period of 21 days using the technique described on page 7. Untreated meadow crop silage (reference silage) was fed in comparison with corn silage allowing the cows a little more of each silage than they would eat. The corn silage had a pH of 4.6, dry matter 23.5%, and sugar 0.27%. The group of 10 cows ate 182.5 lb. of reference silage and 13,054.5 lb. corn silage. This was an average per cow per day of 0.9 lb. of reference silage and 66.0 lb. corn silage. One factor that probably contributed to the palatability of the corn silage was that 72% of the volatile fatty acids of the corn silage were acetic acid. Without exception every cow ate more corn silage each day of this trial.

Bender (7) has pointed out that "grass silages do not contain enough energy to serve as an only roughage for dairy cows. He stated that corn silage or grain is needed as a supplement. King (27) calculated that corn-preserved silages would require 500 lb. of corn per ton to permit corn-treated silage alone to meet the needs of cows in heavy production. Both absolute and comparative palatability measurements showed corn silage to be more palatable than untreated-meadow crop silage.

SILAGES FROM SWEET-SUDAN-SOYBEAN VS. UNTREATED MEADOW-CROP (Series I)

The sweet sudan-soybean silage referred to in the above experiment was fed to the same 12 cows using the same feeding technique in comparison with untreated meadow crop silage of 21% dry matter content. Again the sweet sudan-soybean silage was less palatable, the group averaging 30.8 lb. of soybean-sweet sudan and 38.6 lb. of untreated meadow crop. Ten of the 12 cows preferred meadow crop silage with only two showing a decided preference. Again a changing preference was shown during the progress of the feeding. Both silages were fed in like amounts but the refusal of sweet sudan-soybean silage was 8.6 lb. per cow per day while that of meadow crop silage was only 3.4 lb. Although the sweet sudan-soybean silage was not quite as palatable as meadow crop silage, the sudan-soybean silage would have been satisfactorily accepted as the only silage.

SWEET-SUDAN-SOYBEAN VS. MOLASSES-TREATED MEADOW CROP SILAGE (Series I)

The same 12 cows used in the two experiments described above were divided into two similar groups. One group was fed soybean-sweet sudan silage and the other was fed molasses-treated meadow crop silage for a 10-day period after which there was a 3-day transitional period when all cows were fed equal amounts of both silages.

The group on sweet-sudan-soybean silage ate 55.7 lb. per day as compared with 73.4 lb. of molasses-treated silage eaten by the other group. The former contained 11.7 lb. of dry matter compared to 17.6 lb. in the latter. This much greater dry matter intake by the group on molasses-treated silage occurred irrespective of the fact that the group on sweet sudan-soybean silage produced 3.8 lb. more 4% milk per day which would require about 1.3 lb. of total digestible nutrients, an amount which could be provided by about 10 lb. of sweet sudan-soybean silage.

Following this 10-day period there was a 3-day transitional period. All cows were fed equal amounts of both silages. On the first day the average consumption was 31.3 lb. of sweet sudan-soybean silage and 35.2 lb. of molasses-treated meadow crop. With one exception all cows preferred the new silage that was offered, regardless of kind. On the second day they ate an average of 27.3 lb. sweet sudan-soybean silage and 37.3 lb. molasses-treated meadow crop silage. The cows previously fed sweet sudan-soybean silage preferred molasses-treated meadow crop. Only one cow previously fed meadow crop silage now preferred sweet sudan-soybean silage. On the third day the molasses-treated meadow crop silage was intermixed with wheat silage made from a crop of a too advanced stage of growth which was below it in the silo and the cows definitely declined in total silage intake and ate a higher proportion of sweet sudan-soybean silage than before.

Both group feeding of a single silage and comparative feeding of both silages in a divided manger showed a decided preference of most cows for molasses-treated meadow crop silage over sweet sudan-soybean silage in this experiment.

UNTREATED VS. TREATED HIGH-PROTEIN SILAGES

The complete mixed crop from a legume-grass meadow is herein referred to as meadow crop silage. This type of material has two outstanding advantages for ensiling; it is high in protein and in mineral content. It does, however, have one disadvantage, that of low sugar content for ready fermentation. Many different additives have been used to supply the carbohydrate which would result in a lowered pH. Corn sugar (**41**), molasses (**2, 5, 7, 9, 16, 20, 25, 26, 32, 34, 35, 40, 41,** and **42**), corn or corn-and-cob meal (**3, 27, 34,** and **38**), brewer's dried grains (**2**), and beet pulp (**5**) have been used, usually with considerable success.

Untreated meadow-crop silage has been fed in contrast with four different silages each of which had been treated with such additives. The results of these comparisons follow.

UNTREATED MEADOW-CROP VS. MEADOW CROP SILAGE WITH CONDITIONERS AS ADDITIVES

UNTREATED MEADOW CROP VS. CORN-TREATED MEADOW CROP SILAGE

Experiment 1. Twelve Holstein cows were fed (in Series I) untreated meadow-crop silage in one side of a divided manger and in the other side they were offered corn-treated meadow crop with 193 lb. ground corn per ton of green material. An excess of both silages was fed and the refuse weighed back. The silages were fed alternately in one side of the divided manger and then in the other to eliminate bias from the experiment. A 10-day trial of comparative palatability was carried out during which the 12 cows ate 65.4 lb. (84% of total silage intake) of corn-treated meadow-crop silage and 14.4 lb. (16%) of untreated meadow crop. The corn-treated silage was evidently more palatable.

Experiment 2. The above described experiment was followed by a double reversal experiment (also Series I) in which the same rations were fed. One group of 6 cows was fed untreated meadow-crop silage **ad lib.** and the other corn-treated. Both groups were fed the same grain mixture at a ratio of 1 lb. of grain for each 3 lb. of 4% milk produced. The rate of hay feeding varied from 10 to 14 lb. depending on the size of the animal. More hay was eaten by the cows when fed untreated meadow-crop silage. Table 2 presents the data for this trial. For the first period the dry matter analyses were the same as for the previous trial. For the second and third periods the dry matter content of the untreated silage was 25.5% and of the corn-treated, 27.5%. Regardless of the higher dry matter content of the corn-treated silage the cows ate 71.1 lb. daily as compared to 65.0 lb. while on untreated silage. The resulting 3 lb. greater dry matter intake in the corn-treated silage was accompanied by a lower consumption of hay and grain which partially compensated for the greater dry matter intake in the silage. While on corn-treated silage the groups took 49.6% of their dry matter intake in the form of silage but only 44% while on untreated silage. The percentages of dry matter taken in as grain were 24.2 for corn-treated silage and 26.8 for untreated. The 71.1 lb. of corn-treated silage contained 0.63 lb. of ground corn. This corn would be equivalent to the extra grain eaten (0.4 lb.) while on untreated silage and the nutrients of the additional hay.

Evidence obtained on the preference of the cows during the transitional periods between the experimental periods of this double reversal trial as well as that from experiment one above indicates a preference of most of the cows for corn-treated meadow crop silage over the untreated silage.

Experiment 3. A third experiment was conducted comparing untreated and corn-treated meadow crop for a 16-day period (Series II). Ten cows were used, following the technique described on page 7. The corn-treated silage had 150 lb. of corn meal added per ton. They ate 21.0 lb. of reference silage and 37.7 lb. of corn-treated meadow-crop silage per cow daily. This comparison shows a very decided preference for corn-treated meadow-crop silage.

TABLE 2.—Feed Intake and Milk Production for a Double Reversal Experiment in which Untreated Meadow Crop and Corn-treated Meadow Crop Silages were Fed

Silage	Period	Days	Silage	Silage D.M.*	Hay	Hay D.M.	Grain	Grain D.M.	Total ration D.M.	4% milk	Silage D.M. × 100 / Total Ration D.M.
			(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(%)
Corn-treated meadow crop											
	1	10	4,571.5		657.0		620 0			2,037.0	
	2	8	3,413.5		535.0		496.0			1,542.0	
	3	11	4,387.0		762.5		685.0			2,106.0	
Total		174	12,372.0		1,954.5		1,801.0			5,685.0	
Per cow per day			71.1	18.4	11.2	9.7	10.4	9.0	37.1	32.6	49.6
Untreated meadow crop											
	1	10	3,917.5		723.5		650.0			1,993.0	
	2	8	3,566.5		519.0		514.0			1,573 0	
	3	11	3,841.0		801.0		710.5			2,015.0	
Total		174	11,325.0		2,043.5		1,874.5			5,581.0	
Per cow per day			65.0	15 4	11.7	10.2	10.8	9.4	35.0	32.0	44.0

*D.M. = Dry Matter.

The untreated silage contained 20.75% dry matter and 9.75% protein as compared with 23.5% dry matter and 11.12% protein in the corn-treated silage. The higher protein of the corn-treated indicates variability of the material which was used in making the two silages.

Altogether the three trials show a decided preference for corn-treated meadow-crop silage over the untreated product.

UNTREATED MEADOW-CROP VS. MOLASSES-TREATED MEADOW-CROP SILAGE

Allred **et al.** (2) found the net value of forage lost by fermentation per ton of silage to be $1.36 for untreated red clover and grass (unwilted), but only 26¢ for the molasses-treated silage. The same two groups of cows that were used in the experiment described on page 7 were used for this single reversal experiment (Series II). The group that had been on untreated meadow crop silage in the last comparison remained on this silage for this trial. The group that had been on corn-treated meadow crop in the last comparison, was changed to molasses-treated silage.

Molasses was added to chopped meadow crop at the blower at the rate of 60 lb. of molasses per ton of crop.

Table 3 presents the data of this trial (Series I). The group that had eaten an average of 65.0 lb. of untreated meadow crop silage in the previous trial ate 74.9 lb. daily in the first 8-day period of this trial. Whereas the dry matter intake in silage was 15.4 lb. daily in the previous trial it was 15.8 in the first period presented in Table 3. The group on molasses-treated meadow crop silage ate 65.9 lb. daily per cow indicating that it was less palatable than the untreated with which it was compared in this trial. It evidently was less palatable also than the corn-treated meadow crop fed to the same cows in the previous trial; this is more evident when we compare the dry matter intake when on corn-treated (18.4 lb. daily) with their intake while on this trial (14.5).

They ate less total dry matter during this period, therefore, reduced consumption of the moist silage was not due to appetite being satiated by high energy intake.

The dry matter intake from silage was 44% of the total dry matter of the ration. Both groups were equally efficient in producing milk from either source of dry matter.

At the conclusion of the first 8-day period the silages were reversed on the two groups of cows. The hay and grain allowance remained unchanged. The total for the two 8-day periods when on untreated and on molasses-treated silage are also presented. While the milk production had decreased 2 to 3 lb. daily the hay and grain consumption

TABLE 3.—Data from Experiments Comparing Untreated and Molasses-treated Meadow Crop Silage

Silage	Period	Days	Silage	Silage D.M.*	Hay	Hay D.M.	Grain	Grain D.M.	Total ration D.M.	4% milk	Silage D.M. × 100 / Total Ration D.M.
			(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(%)
Experiment 1											
Untreated											
	1	8	3,598.0	759.1	573.0	498.5	520.4	452.4	1,710.0	1,501.0	44.4
	2	8	3,046.0	642.7	593.0	515.9	488.0	426.6	1,583.2	1,283.0	40.6
Total		96	6,644.0	1,401.8	1,166.0	1.014.4	1,008.0	877.0	3,293.2	2,784.0	
Per cow per day			69.2	14.6	12.1	10.5	10.5	9.1	34.2	29.0	42.5
Molasses-treated											
	1	8	3,166.0	696.5	541.5	471.1	486.5	423.3	1,590.0	1,412.0	43.8
	2	8	3,575.5	786.6	574.0	499.4	520.0	452.4	1,738.4	1,467.0	45.2
Total		96	6,741.5	1,483.1	1,115.5	970.5	1,006.5	875.7	3,329.3	2,879.0	
Per cow per day			70.2	15.4	11.6	10.1	10.5	9.1	34.6	30.0	44.5

*D.M. = Dry Matter.

remained the same as in the previous trial for which the data are presented in Table 3. This resulted in a decrease in the percentage of the total ration dry matter intake that came from silage for both treatments.

As there was adequate silage remaining the cows on both silages were continued for an additional 20 days. The average daily consumption of silage and milk production were almost the same as during the second 8-day period in Table 4. This would indicate that the experimental period was long enough for this single reversal type experiment.

The combined data of the two 8-day periods of the experiment presented in Table 3 indicate a preference for molasses-treated silage over the untreated in contrast with the results for the first 8-day period. They ate the molasses-treated silage in preference to hay. Milk production was actually higher when the cows were fed molasses-treated silage although the difference is not considered significant.

UNTREATED MEADOW-CROP VS. MEADOW CROP TREATED WITH MOLASSES DRIED ON CORN GERM MEAL

This comparison (Series II) was made with the same 10 cows as were used in the above comparison and with the technique described on page 7.

"Omolass" is the proprietary name for molasses dried on corn germ meal. This product contains 85% molasses, is free-flowing and convenient to apply to a load of chopped forage. It was added at the rate of 31 lb. per ton. This amount carried 25 lb. of actual molasses. The manufacturer recommends 25 lb. per ton. For a period of 14 days the average intake of reference silage was 30.5 lb. and of Omolass-treated was 28.0. The dry matter content was 20% for reference silage and 21% for Omolass-treated; the difference in moisture content does not account for the difference in palatability. There was considerable difference between individual cows in their preference of the different silages offered. However, all cows seemed consistent in their preference from day to day.

The rate of application of "Omolass" recommended by the manufacturer does not seem high enough in view of the molasses used and its effect on palatability in other experiments.

UNTREATED MEADOW-CROP VS. MEADOW CROP TREATED WITH MOLASSES ON GROUND CORN COBS (Series II)

This product which will be referred to as sweet mix is made by mixing 45 lb. of blackstrap molasses with 55 lb. of ground corn cobs. The treated silage was prepared by spreading 66.7 lb. of the sweet mix (equivalent to 30 lb. of molasses) per ton of chopped forage on the top of the load. Unloading from the self-unloading wagon and distribution in the silo seemed to mix the materials effectively. The dry matter content of the untreated silage was 21.5% and of the sweet mix-treated was 20.5%. The technique described on page 7 was followed in this 14-day trial. The cows ate 30.0 lb. reference silage and 31.3 lb. of sweet mix-treated silage daily. This 4% greater intake would indicate only a slight preference for the treated silage. There was more variability of the preference of individual cows than was evidenced on the last trial discussed above.

UNTREATED MEADOW CROP VS. MEADOW CROP TREATED WITH CHEMICAL PRESERVATIVES

Any unfermented residue of silage conditioners will add to the feeding value of the silage. Chemical preservatives have no energy value. Conditioners as well as preservatives reduce the amount of fermentation of available carbohydrate of the crop. Therefore a part of the cost of the additive in the cases of both conditioners and preservatives is compensated by a saving of fermentable carbohydrate of the ensiled crop.

UNTREATED MEADOW-CROP SILAGE VS. SULFUR-DIOXIDE-TREATED MEADOW-CROP SILAGE

Knodt (**28**) presented the first comprehensive report on sulfur dioxide (SO_2) preserved silage. He found that this type of silage and hominy-preserved grass silage produced similar amounts of milk. In a later publication Skaggs and Knodt (**37**) reported the ensiling of grasses, legumes, and their mixtures in 50 gallon steel drums. Archibald (**5**) reported on SO_2 and molasses silages and showed that SO_2 reduced fermentation of the sugars while molasses accentuated fermentation of sugars and formation of organic acids. He found that not only sugars but probably fiber also was converted to organic acids. Opinions differ regarding the acceptability of SO_2 and molasses preserved silages. Dufour **et al.** (**14**) found SO_2 preserved silage slightly more acceptable than untreated silage. They reported no statistically significant difference between these silages for milk production or body weight changes. Archibald (**5**) found the reducing sugar of SO_2 legume silage about five times as high as that of untreated silage. He showed that SO_2 reduced the fermentation of sugar in both grasses and legumes, reducing or preventing formation of butyric acid. Lactic acid formation predominated.

Colovos **et al.** (10) conducted energy and protein balance studies with dairy heifers which showed the digestibility and the utilization of the nutrients of SO_2 silage to be greater than those of molasses-treated timothy or oat silage. Keener **et al.** (24) demonstrated that about two-thirds of the S^{35} of radio-active sulfur was absorbed and then eliminated by the kidneys. While there was a lag of two days in elimination by feces, the lag was of only 54 hours **via** kidneys.

A 10-day comparison (Series I) of untreated and SO_2-treated meadow crop silages in divided mangers was made using the technique described on page 7.

The silage was prepared by inserting a hollow tube two feet beneath the surface of the silage and introducing SO_2 gas from a cylinder at a rate that would give 5 lb. per ton of material treated. The SO_2 was introduced at points two feet apart in concentric circles two feet apart over the entire silo surface. The SO_2, a liquid when under pressure in the cylinder, vaporizes on absorption of heat. When the liquid or gas contacts the moist silage the SO_2 is absorbed in the moisture and forms an acid which quickly lowers the pH and reduces fermentation of the sugars.

The data for this trial are presented in Table 4.

TABLE 4.—Silage Composition, Feed Consumption and Milk Production of Cows Fed Untreated and Sulfur-dioxide-treated Meadow Crop Silage in Divided Mangers

	Silages		
	Untreated		Sulfur-dioxide treated
Composition:			
Dry matter, (%)	18.00		26.00
pH	4.97		4.39
β-carotene, air dry basis, (**p.p.m.**)	178.00		170.00
Sugar, air dry basis, (%)	.089		11.40
Consumption:			
Silage eaten, (**lb.**)	16.0		55.8
Silage eaten, (%)	22.3		77.7
Hay, (**lb.**)		12.2	
Grain, (**lb.**)		10.7	
Production:			
Milk, 4 %, (**lb.**)		35.6	

The SO_2-treated silage was preferred by all 12 cows, their intake of SO_2 silage varied from 69 to 82% of the total silage intake. Since all cows had both silages, the milk production and other feed intake are unessential to consideration of preference for silage.

UNTREATED MEADOW CROP VS. MEADOW CROP TREATED WITH KYLAGE

Limited experimental work has been done in the United States with Kylage (calcium formate and sodium nitrite) which is known as Kofa in European countries. Kylage releases formic acid which acts as a preservative. The sodium nitrite readily inhibits development of some microorganisms detrimental to silage formation. Martin and Buysse (**30**) found that Kylage reduced butyric acid formation and increased acetic acid formation in unchopped forages but had little effect when the forage was chopped. Gordon (**18**) had better results with sodium bisulfite than with Kylage. He concluded that Kylage improved the quality, odor and palatability in comparison with untreated silage, but he found wilting more satisfactory. Kendall **et al.** (**25**) did not favor the use of Kylage where it was desirable to preserve high concentrations of carotene.

To test the use of Kylage, meadow crop silage treated with 4 lb. of Kylage per ton was fed in comparison with untreated meadow crop silage.

Kylage can be spread readily on the load and mixed sufficiently when unloaded and distributed in the silo. In this case the Kylage was dissolved and sprinkled on the load of forage to get even distribution for experimental purposes. The Kylage-treated silage had a protein content of 12.06% on an air dry basis while the reference silage (untreated) had 9.93%. The dry matter content was 25.5% for the Kylage-treated and 22.0% for the reference silage. The Kylage- treated contained 0.91% sugar as compared with 0.20% for the reference silage. The volatile fatty acid content of the Kylage-treated was only 40% as high as that of the reference silage. There was a greater reduction in the butyric and propionic acid than in the acetic resulting in a bland silage. There was a large amount of lactic acid in the Kylage-treated. The Kylage resulted in reduced free ammonia nitrogen production by decreasing protein degradation. Over a 10-day period the 10 cows ate an average of 9.3 lb. of reference silage and 44.3 lb. of silage from Kylage-treated crops. This represents 80.7% silage made with Kylage.

COMPARISON OF MEADOW CROP SILAGES MADE WITH DIFFERENT TREATMENTS

It is desirable not only to know how silages made from treated crops compare with those from untreated meadow crops but also how treated silages compare with each other. In order to ascertain the relative effects of treatments on palatability it is necessary to compare them directly. Although it would be desirable to establish a standard of reference this process would require a series of comparisons more extensive than those herein reported. Absence of such a standard is due to the fact that the original purpose of some of these experiments, from which data are taken, did not provide for the adoption of one standard of reference for all silages.

MEADOW CROP SILAGES MADE WITH SIMILAR ADDITIVES

In the following experiments comparisons were made of treated meadow crop silages where both organic additives and chemical preservatives have been used. Molasses and moldy corn are similar because both supply fermentable carbohydrates, both seem to stimulate fermentation in the same way, and to result in similar finished silages.

SILAGES MADE FROM MOLASSES-TREATED MEADOW-CROP VS. MEADOW CROP WITH MOLDY CORN AS CONDITIONER

Treatment of meadow crop with molasses when it was applied under the proper conditions has improved the palatability of the silage. Ground shelled corn and ground ear corn were highly satisfactory for treatment of chopped meadow crop.

For this comparison one silage was made by addition of 60 lb. of blackstrap molasses at the blower, the other by addition of 150 lb. of ground moldy ear corn per ton of field-chopped meadow crop. Moldy immature ears do not have the feeding value of an equal weight of No. 2 corn, but if it serves well as a conditioner its full potential feeding value should be realized.

Two groups of six comparable cows were used to test the palatabilities of these silages. Both groups were fed similarly with respect to hay and grain. The group fed silage from molasses-treated crops ate an average of 71.0 lb. per cow per day whereas those on moldy corn-treated meadow crop silage ate 78.3 lb., both for a 5-day period. The six cows fed moldy corn-treated silage varied from 57.5 to 105.5 lb. per day during the 5-day period. The group on molasses-treated varied from 52 to 85.5 lb. Evidently both silages were highly palatable and useful silages.

It is worthy of note that neither the silage made with moldy corn nor the corn residues showed any mold in the silo. This is probably because molds require oxygen for growth and oxygen was absent from this silage.

SILAGE MADE FROM SULFUR DIOXIDE-TREATED MEADOW CROP VS. BISULFITE-TREATED MEADOW CROP

Preliminary experiments at the Ohio Agricultural Experiment Station comparing sulfur dioxide-treated meadow crop silage with untreated silage had shown that sulfur dioxide was an excellent preservative. The inconvenience of application of the sulfur dioxide caused this Station to withhold recommendation of the practice. When sodium bisulfite was shown (**11**) to be a practical treatment the following experiment was conducted.

Meadow crop silages were prepared (1) by application of 5 lb. of liquid sulfur dioxide per ton injected at two foot intervals over the surface of the fill and for the depth of the fill by 2- to 3-foot layers, (2) by the addition at another silo of 8 pounds of sodium bisulfite per ton of crop. The bisulfite was sprinkled over the top of the load in 3 gallons of solution for each ton on the load.

Expressed as elemental sulfur, the sulfur dioxide supplied 2.5 lb. of sulfur per ton, and the bisulfite 2.7 lb. per ton. These are respectively, 0.125% and 0.135% of the weight of the crop.

The data which characterize the two silages are presented in Table 5. It will be noted that in many ways the effects of the two preservatives are the same. The pH of sulfur-dioxide silage is lower and the titratable acidity was greater, perhaps because of the unneutralized sulfurous acids formed from chemical reaction of the sulfur dioxide and the plant juices. The preservation of sugar by both forms of sulfur dioxide is evident. This action by bisulfite has been noted by Alderman (**1**), Bratzler (**8**) and Gordon (**17**). Suppression of butyric and propionic acid formation with increase in the proportion of acetic and lactic by both preservatives is also evident. Likewise β carotene was well preserved by both.

Two groups of nine cows each were selected as equally matched as possible according to their former production, present production, size, age and breed. These groups were fed through a preliminary period and a double reversal trial with 10-day transition periods. Each period of the double reversal consisted of three 10-days periods except for one period of 8 days. For this reason all data are given in Table 6 in terms of per cow per day.

In the beginning both groups were fed grain of 12.5% protein in proportion to milk production. When milk production declined grain

TABLE 5.—Composition of Silages made from Meadow Crops Treated with Sulfur Compounds

	Sulfur-dioxide treated		Bisulfite treated	
Sample	1	2	1	2
Dry matter, (%)	27.5	27.5	25.0	26.0
Sugar, dry basis, (%)	3.3	5.8	4.2	5.5
Sulfur, dry basis, (%)	0.7	0.7	0.8	0.7
Protein, dry basis, (%)	10.3	13.4	11.1	15.0
β-carotene, dry basis, (mg./g.)	202.0	266.0	204.0	269.0
pH	4.5	4.4	4.7	4.7
Titratable acidity*	237.0	200.0	124.0	108.0
Volatile fatty acids*	140.0	97.0	115.0	69.0
Butyric acid*	13.8	1.2	2.4	0.8
Propionic acid*	4.6	1.2	55.2	1.2
Acetic acid*	85.8	44.2	51.4	33.0
Lactic acid*	232.0	136.6	198.9	112.8

*Milliliters of 0.10 N alkali required to titrate the acids of 100 milliliters of silage juice.

TABLE 6.—Feed Consumption and Milk Production per Cow per Day when Fed Sulfur-dioxide and Bisulfite-meadow-crop Silages

				Pounds of Silage Eaten					
Period	Group	Hay	Grain	Sulfur dioxide, fresh	Sulfur dioxide (Dry matter)	Bisulfite, fresh	Bisulfite, (Dry matter)	4% milk	Weight change*
		(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)
Preliminary	1	7.4	10.3	48.3		----		40.0	+ 1
	2	7.5	10.4	----		50.2		37.0	+ 9
Experiment I	1	7.1	10.6	51.7	13.3	----		37.7	+ 9
	2	7.4	9.9	----		56.4	14.0	35.1	+ 7
Transition	1	7.3	10.3	----		54.5		35.2	
	2	7.4	9.6	60.2		----		32.1	
Experiment II	1	7.4	9.7	----		55.6	13.4	32.3	—13
	2	7.4	9.2	60.4	15.6	----		31.3	0
Transition	1	7.4	9.3	54.1		----		30.1	
	2	7.4	8.9	----		61.9		30.1	
Experiment III	1	7.4	9.1	49.9	13.6	----		30.3	+10
	2	7.4	8.7	----		62.0	15.7	29.1	+ 6
Average (3 periods)									
On SO_2-silage		7.3	9.6	54.0	14.2	----		33.1	+ 6
On bisulfite-silage		7.4	9.4	----		58.0	14.4	32.2	0

*Weight change is per cow for the period indicated. + increase
— loss

feeding was reduced to both groups at the same rate. Hay containing 12.8% protein was fed to all cows at the rate of 0.7 lb. hay per 100 lb. of body weight. The greater average daily milk production for group 1 in each period is evident in Table 7. Group 1 also produced more in the second period when they were fed bisulfite silage. The dry matter percentage of the bisulfite silage was consistently higher than that of the sulfur dioxide silage. The slightly higher daily dry matter intake seems to be not significant. While the cows were fed sulfur-dioxide silage they ate only 54.0 lb. as compared to 58.0 while on bisulfite silage; however, while on sulfur-dioxide silage they produced 1.15 lb. of 4% fat corrected milk per pound of dry matter in the ration as compared to 1.11 while on bisulfite silage (not a significant difference).

The palatability of these two silages seemed to be nearly equal. The values of the two silages per pound of dry matter for milk production were approximately equal.

The production of bisulfite silage would be preferable because of the convenience of adding this preservative.

MEADOW CROP SILAGES MADE WITH DISSIMILAR ADDITIVES

Because of the different characteristics of the silages made by use of conditioners and preservatives and because both types of additives improve the quality of the finished silage a comparison of the two types of silages was desirable.

SILAGES FROM CORN-TREATED MEADOW CROPS VS. SULFUR DIOXIDE-TREATED MEADOW CROPS

Experiment 1. The test animals were assigned to two groups of fifteen each as equally as possible with respect to age, breed, previous production and stage of lactation.

All cows were fed a 13.5% protein grain mixture; to Jerseys at the rate of one pound per 3.5 lb. of milk and to Holsteins at the rate of one to 4.5 lb. The ratio eaten proved to be 1 pound to each 3.5 lb. of 4% milk for all the cows.

TABLE 7.—Some Components of Meadow-crop Silages

	Corn—treatment		SO_2—treatment	
	Period 1	Period 2	Period 1	Period 2
Acidity as pH	4.63	4.4	4.81	5.6
Dry matter (%)	27.0	24.0	19.0	20.0
Sugar, dry basis, (%)	0.56	0.54	0.33	0.19
β-carotene, dry basis, (p.p.m.)	110.0	121.7	251.6	181.5

TABLE 8.—Pounds of Feed Consumption, Milk Production and Weight Changes per Cow per Day in Two Feeding Trials Comparing Meadow Crop Silages made with 3 Treatments

Treatment of meadow crop	4% milk pro-duced	Hay eaten	Grain eaten	Silage eaten	Silage dry matter eaten	Total ration dry matter	Weight change
	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)
Trial 1							
Corn	27.5	3.7	8.1	58.6	15.8	26.0	+0.7
Sulfur-dioxide 4 lb./T of crop	27.8	3.6	7.9	56.4	10.7	20.7	—1.0
Trial 2							
Corn	29.1	4.1	8.9	58.9	14.1	25.4	+0.8
Sulfur-dioxide 6 lb./T of crop	28.9	4.4	8.6	51.0	10.4	21.7	+1.1
Weighted Averages							
Corn	28.4	4.0	8.6	58.8	14.9	25.7	+0.8
Sulfur-dioxide	27.6	4.0	8.3	51.9	10.5	21.2	+0.3

The milking Holsteins were offered 6 pounds of hay daily and the Jerseys 4 pounds. The hay was low-quality alfalfa and the amount refused was great.

The first feeding period was for 17 days. The second period (28 days) followed immediately; there was no reversal. The sulfur dioxide-treated silage fed during the first period was treated at the rate of 4 pounds of liquid sulfur dioxide per ton; the second at 6 pounds per ton.

Table 7 gives the composition of the two silages for each period and Table 8 gives the data for both feeding periods.

The greater milk production and daily gain in body weight of the group on corn-treated silage would require 2.02 pounds more of total digestible nutrients according to Morrison's standards.[2] The 4.5 lb. greater dry matter intake would yield about 2.5 pounds of total digestible nutrients. This indicates slightly less efficient use of energy by the group on the higher level of dry matter intake. The computed yield of 4% milk produced per pound of grain consumed shows much greater efficiency of the group on sulfur-dioxide silage, but this is largely accounted for by the smaller intake of grain.

The sulfur-dioxide silage prepared by the addition of 4 pounds of sulfur dioxide was much more palatable than that prepared by use of 6

[2]Feeds and Feeding, 22nd Ed. F. B. Morrison, The Morrison Publishing Co., Ithaca, New York, 1956.

pounds. If there was a method for introducing the sulfur dioxide evenly throughout the mass without loss of the gas even less than 4 pounds might be adequate. Such a method has not been suggested.

Experiment 2. For the second experiment two groups of seven cows each were used. Both groups were fed 8 pounds of alfalfa hay per animal daily. Grain was fed at the rate of 0.4 lb. per lb. of milk above 20 lb. to Holsteins and at the rate of 0.5 lb. per lb. of milk above 12 lb. for Jerseys. Adjustments in grain allowance were made at each 10-day period. Hay and silage were fed separately once daily after grain feeding and the refuse weighed back.

For a 10-day period all cows were fed the hay and grain according to plan, and silage as a mixture of equal amounts of the two silages so that all would have a common background of treatment. Both groups were then placed on a preliminary period on their respective silages. This was followed by five 10-day experimental periods, a 10-day transitional period when the silages were reversed and then by five more 10-day experimental periods: a single reversal experiment. All cows were given as much silage as they would consume.

The sulfur-dioxide silage was prepared by injecting 5 lb. of liquid sulfur dioxide per ton of chopped material in place in the silo. The meadow crop silage made with corn was prepared by spreading 150 lb. of ground ear corn per ton of chopped material on the wagon before unloading. The two silages were made in a 14-foot silo by dividing the silo by a vertical partition of boards and Sisalkraft paper. Alternate loads were used in either half of the silo and treated as explained in detail above.

Table 9 gives some analyses of the two silages and the hay at significant points of the experiment. The protein content of the hay and silages indicates that silages might be substituted for hay without detriment. In only one 10-day period was the dry matter content of the sulfur dioxide silage greater than that of the silage made with added corn. The average dry-matter content for the ten periods and the transition was 28.4% for the sulfur dioxide-treated and 30.3% for the silage made with added corn. Addition of 150 lb. of ground ear corn would raise the dry matter content from 28.4% to 32.5% if there was no loss from fermentation.

The percentage of sugar still remaining in the sulfur-dioxide silage (Table 10) for the 2nd reversal period indicates that the sulfur dioxide inhibited fermentation. The greater concentration of acetic and lactic acids in the silage from the corn treatment probably arise from fermentation of sugar of the crop and of the ground ear corn.

TABLE 9.—Analyses of Sulfur-dioxide and Corn-treated Silages and of Hay

Period	Silages from meadow crops treated with silage		
	Sulfur-dioxide	Corn	Alfalfa Hay
1st Experimental:			
Dry matter, (%)	29.8	34.1	
β-carotene, dry basis, (p.p.m.)	115.7	90.3	
Protein, (%)			12.2
3rd Experimental:			
Dry matter, (%)	27.0	32.0	
β-carotene, dry basis (p.p.m.)	153.3	76.6	17.5
Protein, (%)	11.6	10.2	
4th Experimental:			
Dry matter, (%)	27.5	29.0	
β-carotene, dry basis, (p.p.m.)	159.6	131.4	39.8
Protein, (%)	12.3	11.4	12.4
2nd Reversal:			
Dry matter, (%)	28.0	30.0	
β-carotene, dry basis, (p.p.m.)	178.6	147.7	9.7
Sugar, dry basis, (%)	5.4	0.8	
Sulfur, dry basis, (%)	1.4	0.4	
Acetic*	60.6	151.0	
Lactic Acid*	163.8	455.6	
3rd Reversal:			
Dry matter, (%)	29.0	32.0	
β-carotene, dry basis, (p.p.m.)	191.4	161.8	45.2
4th Reversal:			
Dry matter, (%)	28.0	30.0	
β-carotene, dry basis, (p.p.m.)	166.1	132.7	35.0
Sugar, (%)	4.93	0.6	
Sulfur, dry basis, (%)	1.01	0.27	
Titratable acidity*	217.0	463.0	
Volatile fatty acid*	101.5	150.5	
Acidity (as pH)	4.05	3.85	

*Milliliters of 0.10 N NaOH to titrate the acidity of 100 milliliters of juice.

The β-carotene content of the sulfur-dioxide silage is consistently greater than that of the corn-treated silage. Since the β-carotene content is expressed in parts per million on the dry basis, the addition of 150 lb. of ground ear corn (with small β-carotene content) to the ton of green material would reduce the p.p.m. of β-carotene to the same degree as the increase in dry matter content. In this case the added dry matter was 23% of the dry matter in the crop which approximates the reduction of the p.p.m. of β-carotene of the silage made by the corn treatment. Apparently the β-carotene loss is not accentuated by the fermentation of added carbohydrate.

A resumé of feed consumption and milk production data is presented in Table 10. It will be noted that the group which had corn-treated silage during the first 50 days ate almost exactly the same amount of dry matter in silage when it was changed to sulfur-dioxide silage for the reversal 50 days. The group that had been on sulfur-dioxide silage for the first 50 days and losing weight increased its intake of dry matter in silage and gained in weight when changed to corn-treated silage. The changes in weight for the 100 days are relatively small.

When the total intake of dry matter for the cows eating sulfur-dioxide silage is corrected for the dry matter equivalent to the loss of body weight the milk production equals 1.08 lb. per lb. of dry matter intake while the groups when on silage from corn-treated crop produced 1.13 lb. of milk per pound of dry matter intake.

Digestion trials (**12**) were run using two additional cows and the same roughages and grain as were used in this experiment.

Table 11 presents some of the data from these trials. The same digestibility of dry matter for cow 910 is apparent for trials 1 and 5. This is higher than for trials 2, 3 and 4 when no grain was fed. The same relationships are seen for cow 914. Removal of grain from the ration in trial 2 for both cows reduced the percentage of digestibility as compared with trial 1. Removal of grain in trial 2 lowered the dry matter digestibility while removal of clover hay on trial 3 raised the digestibility. Comparison of the coefficients of digestibility of dry matter for cows 910 and 914 in trials 1 and 2 indicate that the treatment of the silage with ground ear corn increases the digestibility. According to Morrison, the fiber of average alfalfa is 53% digestible and that of corn 57%. Apparently the greater digestibility of the corn residues in the corn-treated silage is responsible for the higher coefficients for the corn-treated silage.

The acidity of the urine from cows on sulfur-dioxide silage rose (pH declined). This is undoubtedly the result of excretion of sulfates.

TABLE 10.—Feed Consumption, Milk Production and Body Weight Changes of Cows on Silages from Corn-treated and Sulfur-dioxide-treated Meadow Crops

Silage Experimental period	Hay	Grain	Silage Eaten	Silage Dry matter	Silage Dry matter	4% milk	Weight change
	(lb.)	(lb.)	(lb.)	%	(lb.)	(lb.)	(lb.)
From corn-treated crop							
1st Experimental			3,626	34.1	1,236		
2nd Experimental			3,533	23.5	830		
3rd Experimental			3,582	32.0	1,146		
4th Experimental			3,721	29.0	1,079		
5th Experimental			3,624	30.0	1,087		
Total— 50 days	2,688	3,504	18,086		5,378	13,128	— 26
1st Reversal			4,048	30.0	1,214		
2nd Reversal			4,041	30.0	1,212		
3rd Reversal			3,971	32.0	1,271		
4th Reversal			4,104	30.0	1,231		
5th Reversal			4,141	30.5	1,263		
Total— 50 days	2,788	2,409	20,305		6,191	11,066	+ 23
Total—100 days	5,476	5,913	38,391		11,569	24,194	— 3
From sulfur-dioxide-treated crop							
1st Experimental			3,872	29.8	1,154		
2nd Experimental			3,726	29.5	1,099		
3rd Experimental			3,892	27.0	1,051		
4th Experimental			3,799	27.5	1,048		
5th Experimental			3,633	28.0	1,017		
Total— 50 days	2,700	2,835	18,922		5,369	11,690	—228
1st Reversal			3,568	30.0	1,070		
2nd Reversal			3,739	28.0	1,047		
3rd Reversal			3,736	29.0	1,083		
4th Reversal			4,043	28.0	1,132		
5th Reversal			3,860	27.0	1,042		
Total— 50 days	2,769	2,761	18,946		5,374	10,695	+176
Total—100 days	5,469	5,596	37,868		10,743	22,385	— 52

TABLE 11.—Digestion Trials Using Two Jersey Cows Fed Two Different Silages

Cow	Trial	Silage* from: Corn-treated crops	Silage* from: Sulfur-dioxide-treated crops	Clover hay*	Grain*	Dry matter digested	Sulfur* in urine	Acidity of urine
		(lb.)	(lb.)	(lb.)	(lb.)	(%)	(g.)	(pH)
910	1	40	--	8	6	62.1	----	----
914	1	--	50	8	6	61.8	----	----
910	2	50	--	8	--	58.6	7.5	8.25
914	2	--	50	8	--	56.9	28.1	8.02
910	3	67	--	--	--	59.7	6.7	7.81
914	3	--	57	--	--	60.0	25.9	6.60
910	4	--	64	--	--	59.9	26.1	7.22
914	4	66	--	--	--	59.6	4.5	8.49
910	5	--	64	--	6	63.8	27.0	----
914	5	--	63	--	6	65.2	30.8	----

*Daily

The pH returns to a normal, higher value when ingestion of sulfur compounds ceases. No physiological abnormalities were apparent even though the pH was low.

UNTREATED SILAGE VS. SILAGE FROM CORN-TREATED VS. SULFUR-DIOXIDE-TREATED MEADOW CROPS

To make this three-way comparison a Latin square design experiment was set up using 9 cows and feeding them for three days. The silages were fed in a divided manger so the cow had equal access to two silages simultaneously. The method of assigning the silages to cows (Fig. 2) was such that in the three days all silage combinations were equally represented and those cows that had the same silage in both sides of the manger had been offered each of the three silages. All possible sequences of one silage following another were obtained by use of this design.

The amounts of silages offered and refused were recorded. The silage consumption is shown in Table 12. The data were tested[3] for components of variance with the result that the components due to days, side of the manger and cows were not significant. The cows ate more

[3]The authors appreciate the cooperation of C. R. Weaver, Dept. of Entomology of the Ohio Agricultural Experiment Station, in analyzing the data.

U = Untreated-meadow-crop silage
C = Corn-treated-meadow-crop silage
S = Sulfur-dioxide-treated-meadow-crop silage

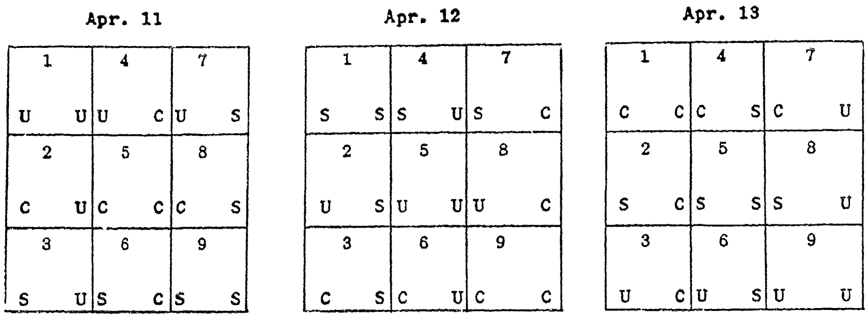

Fig. 2.—The Latin square design used in assigning the three silages to the nine cows on three consecutive days.

than three times as many pounds of silage from corn-treated crops as of the untreated and nearly three times as much as of the sulfur-dioxide silage. The preference for sulfur-dioxide silage over untreated silage was small.

The F value at the 1% level would need to be 5.20 to be significant. It was 20.43 and this was highly significant.

TABLE 12.—The Pounds of Silages from Untreated, Corn-treated and Sulfur-dioxide-treated Meadow Crops Eaten by 9 Cows in 3 Days

Date	April 11			April 12			April 13		
Cow No.	U*	C†	S‡	U	C	S	U	C	S
	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)
1	26.0					29.0		59.0	
2	1.0	45.0		5.0		19.0		66.5	1.0
3	30.0		24.5		68.0	11.0	2.0	63.0	
4	11.5	55.0		12.5		28.0		81.5	0.0
5		62.5		33.0					38.0
6		21.5	14.5	0.5	57.0		13.0		18.5
7	24.0		23.5		53.5	23.5	2.0	62.0	
8		60.0	2.5	10.0	65.5		22.5		6.0
9			32.0		79.0		54.0		
TOTAL	92.5	244.0	97.0	61.0	323.0	110.5	93.5	332.0	63.5

*U=Untreated-meadow-crop silage; total consumed = 247 lb.
†C=Corn-treated-meadow-crop silage; total consumed = 899 lb.
‡S=Sulfur-dioxide-treated-meadow-crop silage; total consumed = 271 lb.

GENERAL DISCUSSION

Differences in palatability of silages cause cows eo eat one silage in preference to another when both are offered. Dairymen become concerned when low palatability of a silage limits its intake. Wheat silage made at too late a stage of growth is a case in point (33); if cows are restricted to this type of roughage for a short period milk production would be quickly reduced to a very low level. When two silages are so similar in palatability as in the case of the comparison of corn silage and untreated meadow crop silage (Table 1) and when the dry matter intake is so nearly the same, this difference in palatability is unimportant. If cows were fed either silage exclusively intake would be satisfactory. Palatability and dry matter are not synonymous. High dry matter content of silage seems to have a long range effect on palatability because of high energy content. Ideally, therefore, comparisons of palatability should be made between silages of similar dry matter content. When such comparisons are made palatability may be expressed in terms of pounds of fresh silage consumed.

There are marked differences in palatability of a single silage to different cows within a herd. A cow that finds a silage unpalatable compensates by eating more hay if the hay is offered free choice. Dairymen may knowingly or unknowingly adjust for such differences in palatability.

British workers (31) point out that the fermentation of chopped crops is different from that of unchopped. All silages referred to in this discussion were chopped. Individual cows show a changing preference when offered two silages simultaneously over a period of time. This changing preference may result from a change in proportions of the organic acids of fermentation, changes which are unnoticed by the feeder. Cows are accustomed to the flavor of organic acids formed by rumen fermentation as these permeate the bolus when they chew their cud.

Many silages, whose odors are objectionable to man, are eaten readily by cows. Man, therefore, must be objective in estimating the palatability of a silage, and refuse to let his personal likes or dislikes bias evaluation of the silage.

When cows are fed two silages of widely different dry matter content in succeeding periods, a feeder is unable to judge differences in palatability due to the effect of dry matter content on the weight of moist roughage consumed. When two silages are fed simultaneously the cow may show a preference if both silages are fed in excess of her needs, in which case the intake of silage is limited by the dry matter (or energy) content of the **combined** silages rather than by either alone.

Two silages made from the same crop (identical in cellulose and lignin content) but with widely different moisture content would undergo different fermentation reactions and so have different percentages of the resulting organic acids. When there is less lactic and acetic acids and more butyric and propionic acids palatability declines. No doubt some of the benefits attributed to conditioners and preservatives are due to such changes. Changes in moisture content may be largely responsible for differences in acceptability of silages made by the same procedure in succeeding years.

In Table 5, titratable acidity is seen to be greater than the amount of volatile fatty acids. The reader should keep in mind that titratable acidity is a measure of free acidity alone. Acids combined as salts are not measured in titratable acidity, however, both free and combined organic acids are measured when silage juices are steam distilled and separated chromatographically. Lactic acid is not a volatile acid and so must be determined in addition to the other acids of lower molecular weight which are volatile.

The effect of a molasses treatment varies with the moisture content of the crop ensiled. With very wet material, molasses causes a withdrawal of moisture from the plant tissues and proportional juice loss results. Such silage is not likely to have superior palatability. When the dry matter content of the crop is higher, molasses has less dehydrating effect, remains for fermentation action and results in a highly palatable silage.

Corn meal and ground ear corn have a double effect; they increase the dry matter content of the silage and provide readily fermentable carbohydrate. Digestion trials showed a higher percentage of digestibility of fiber and absorption of protein when corn was used as a conditioner in comparison with untreated silages from identical crops (**12**). Huffman and Duncan (**22**) replaced part of the hay of an all-hay ration with corn silage and obtained an increase in milk production. They concluded that corn grain contains a stimulating factor (or factors) for milk production. The digestion trials referred to above (**12**) indicate that the available energy of the added corn was necessary to supplement that in the grass silage to obtain better fermentation of the fiber in the rumen.

Dunn, Ely, Huffman and Duncan (**15**) report that the corn in corn silage has the same value as a comparable amount of ground ear corn. Therefore, when silage that has been treated with corn is fed, less grain need be provided.

Theoretically, wilting of the meadow crop makes unnecessary the use of conditioners or preservatives. When wilting is impossible the silo filling operation must continue. Use of ground cereal grains or chemical preservatives reduce the risks of low palatability in silages from crops high in moisture content. Hayden **et al.** (19) in 1937 pointed out the important influence of moisture content of the ensiled crop on the quality of the resulting silage. They called attention to the undesirable odors of silages resulting from use of wet crops and the very favorable silages resulting from crops of 30 to 50 percent dry matter content.

Reports vary with respect to the effects of bisulfite upon silage preservation. That differences in moisture content of the materials ensiled with bisulfite as a preservative may be responsible for variations in quality of finished silage seem probable. Research should be directed toward solution of this problem. The convenience of applying the granular bisulfite either on the load or at the blower and the palatable product often obtained, recommend its use in preference to sulfur dioxide.

The danger that some of the equipment may break and expose the operator to a dense concentration of the fumes of sulfur dioxide makes its use hazardous; furthermore, the sulfur dioxide does not diffuse readily from the point of injection. The silage at the point of injection will be bleached and yellow and may be unpalatable unless mixed with other silage containing less preservative. This same limitation is true for sodium bisulfite when it is not properly distributed and there is not sufficient juice to move the chemical through the mass. Silages made with 4 and with 6 pounds of sulfur dioxide per ton demonstrated that the smaller amount when properly distributed made a more acceptable silage.

Silages properly made with either bisulfite or sulfur dioxide reach a condition in which fermentation ceases in a shorter time than in similar silages not so treated. With less early oxidation occurring more carotene remains in the silage. The higher carotene content of the silage is reflected in more carotene and vitamin A in the milk.

Corn silage is palatable and no preservative is needed at the time of ensiling. Corn silage that was treated with five pounds of sulfur dioxide when ensiled in the same manner as for grass-legume silage proved to be very unpalatable.

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